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The seven conceptual schemes of the National Science Teachers Association (NSTA) publication "Theory into Action" are used to articulate teaching of science K-12. These schemes are amplified by a series of unifying concepts which are described in terms of behavioral outcomes expected of the students at each of four levels, primary, intermediate, junior high and senior high. Each level increases the sophistication of the student's understanding of each conceptual scheme, and in this way a sequence of development is proposed which unifies the separate science subject areas. Also included are safety hints for science instruction, criteria for implementing a science program, and an extensive bibliography of teacher references. (GR)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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STATE OF ALASKA

DEPARTMENT OF EDUCATION

SCIENCE

CURRICULUM GUIDELINES

GRADES K-12

CLIFF R. HARTMAN
COMMISSIONER OF EDUCATION

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1967

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FOREWORD

Science teaching has been undergoing revolutionary changes. Many rather extensive curriculum projects have been conducted or are being conducted to improve the teaching of science in elementary and secondary schools around the nation. Out of these studies are emerging some very definite changes that should be incorporated into our science programs. New methods are needed to help the student develop into an active citizen in tomorrow's rapidly changing world of science and technology.

Todays science curriculum must keep pace with our rapidly changing world. Educators must develop new methods of teaching which will cultivate the natural interests and curiosities of children. Students must be taught the problem solving methods needed to exist in tomorrows rapidly moving technological environment. We must also help him to develop the attitudes and skills which are necessary to solve the many new problems that will confront him.

Rather than build our science curricula on a specific body of facts they should be developed around basic concepts which will probably continue to be valid and can be applied in new situations. The teacher should guide the child toward an understanding of these concepts through meaningful experiences. The child must be allowed to experiement and discover for himself an understanding of these concepts.

These guidelines are not intended to be a finished product. They need to be reviewed and studied by administrators, curriculum supervisors, and teachers. It is hoped that comments and recommendations will be sent to us. This feedback will aid in revising and upgrading these guidelines.

Cliff R. Hartman
Commissioner of Education

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We express our sincere appreciation to all those who contributed of their time and professional judgment to the development of these guidelines.

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PHILOSOPHY

Development of perceptions which bring about changes in the behavior of the learner is basic to our philosophy of science education. To be effective, science education must result in a citizenry which is literate with the language and methods of science--a citizenry able to keep abreast of the ever--expanding body of scientific knowledge.

> Science affects the life of every contemporary man every day. It conditions decisions that need to be made by his government... It affects the decisions made by individuals on business problems, on selecting a community in which to live... If an individual is ignorant of science he must guess what to do or else believe what he is told. Even if he is told what to do by an expert, he has no way to check on this advice or even to understand it. This unhappy predicament is precisely that of most citizens of the United States today. Their fate in important matters and in trivial matters may thus be decided without their participation. And it will not be otherwise so long as they remain illiterate about science and technology.[1]

The committee feels that an adequate science program must be one that has continuity and is planned as an integral part of the total curriculum. Science instruction must assure

> the education of every citizen, in addition to providing the necessary basis for the education of the future professional scientist, engineer, and technologist.[2]

The science program cannot present the child with each and every new discovery. The object of science teaching should be to help each student to develop skills in the use of the scientific process so that he may attain an understanding of the broad concepts underlying

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1 President's Science Advisory Committee, Education for the Age of Science, Washington, D.C., May 24, 1958, p.4

2 President's Science Advisory Committee, p. 6

science. Another goal of science instruction must be to make the student aware of the humanizing aspects of science. Education in Alaska has both the special opportunity and obligation to help the student understand that despite their relative uniqueness both individuals and cultures also have many characteristics in common. The modern science curriculum should help the student to realize that the universe is orderly and is governed by natural laws. It must also make him aware that knowledge and understanding of these laws are continually being tested, revised, and refined.

Science instruction should actively involve the student in the processes of inquiry. Every discovery activity should be conducted in the area most appropriate to its success. Some things can be more accurately observed and better learned beyond the classroom walls. By discovering through experimentation, the student will

> ...feel more at home in the world whose laws he is able to fathom. With each new discovery, large or small, he (will understand) the nature of his environment more clearly and (achieve) a more rewarding relationship to those things about him.[1]

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1 Glen T. Seaborg, "What It Means to Be A Scientist," Address to the National Science Fair, Baltimore, Maryland, May 5, 1964, mimeographed, p. 10.

INTRODUCTION

> Concepts are the summaries of experience; they are inventions of the mind to explain or group certain categories of perceptions, and they are often labeled... Concepts are mental configurations invented to impose order on an endlessly variable environment and to make adequate responses to events a possibility.[1]

The Alaska committee based the structural framework for these guidelines on suggestions contained in Theory Into Action,[2] a report of the Curriculum Committee of the National Science Teachers Association (NSTA). It seemed to the committee that the conceptual schemes approach embodying the major ideas of science could be adapted as the basis for a strong interdisciplinary program of science in Grades K-12. Accordingly, each conceptual scheme was amplified by a series of unifying concepts which, in turn, were described in terms of behavioral outcomes.

The behavioral outcomes encompass those activities which the child performs either to attain or to demonstrate understanding of a concept and its place in the scientific scheme.

The behavioral outcomes have been grouped into four levels: primary (I), intermediate (II), junior high (III), and senior high (IV). Not intended as sharp divisions, these levels sometimes overlap, each consisting of related ideas of progressive sophistication. The teacher should evaluate the student's achievement of previous behavioral objectives before attempting to proceed on any particular level. To meet the needs of individual students, the teacher may find it beneficial to use activities from other levels.

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1 Herbert A. Smith, "The Teaching of a Concept: An Elusive Objective," The Science Teacher, Vol. 33, No. 3, March, 1966, p. 105.

2 National Science Teachers Association, Theory Into Action in Science Curriculum Development, National Education Association, Washington, D.C., pp. 20-21.

INTRODUCTION

The unifying concepts as developed in these guidelines are in tended to be useful with any of the adopted textbook series and in a variety of school situations from very small to very large enrollment.

While it is left to individual teachers and local curriculum committees to determine specific scope, sequence, and activities in applying these guidelines to local situations, it is hoped that the individual teacher will recognize the conceptual schemes as comprising a skeleton which supports the body of scientific knowledge, and that he will realize that these are the great ideas of science which are being amplified whenever text materials are presented and experiements performed. It is not intended that a youngster should ever be tested on the conceptual schemes and unifying concepts per se: these statements should guide the teacher's approach to the subject matter so that its value to the student will be enhanced no matter what his age or how great or small his interest in the field. It is felt that if material is presented in these terms the study of science will no longer be rote memorization but will develop understandings valuable to a student throughout his life.

While the schemes and concepts themselves may appear very sophisticated, they can be taught at many levels of understanding, and source books and such pamphlet series as Investigating Science with Children, [3] and Science - A Process Approach [4] may prove especially helpful in suggesting methods appropriate to a given leve. For example, the discussion of wave lengths, amplitudes, and frequency may at first appear beyond the grasp of the elementary student, but these ideas can be presented in a very understandable manner by means of demonstrations outlined in this type of series.

A series of conceptual schemes adapted from the recommendations of the NSTA Committee was used as the basis for the development of the unifying concepts and the behavioral goals in these guidelines. The processes of science were adapted from the American Association for Advancement of Science. [5] The schemes and the unifying concepts were determined by the committee responsible for these guidelines.

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3 National Science Teachers Association, Investigating Science With Children, Teachers Publishing Corporation, Connecticut, 1964.

4 Science - A Process Approach, American Association for the Advancement of Science, Washington, D. C., (1965).

5 Ibid

INTRODUCTION

The number coding used in the body of these guidelines is as follows: the conceptual schemes are designated by Roman numerals I-VII. Unifying concepts are designated by two digits such as 2-1, 2-2, 2-3, etc. Behavioral outcomes are referred to by using three digits such as 2-11, 2-12, 2-13, etc. For example, in the number 2-34 the 2 designates a relationship to conceptual scheme II. The 3 refers to the third unifying concept under conceptual scheme II. The 4 indicates the fourth behavioral outcome under unifying concept three.

To assist the secondary teacher, the behavioral outcomes in level IV have been keyed with B for Biology, C for Chemistry, P for Physics, P.S. for Physical Science, and E. S. for Earth Science. Some that would apply to all areas and are indicated as A.

The objectives of the science program are the goals toward which the teacher organizes his teaching procedures. The behavioral outcomes listed under the unifying concepts allow the teacher to evaluate progress toward these goals according to the level of the student's education. It is hoped that by the completion of Grade 12 all these objectives will have been achieved. Inherent in the program is the idea that the student's education is never complete, but that with the concepts, skills, attitudes, and insights gained in his science education, he will continue to learn on his own.

OBJECTIVES

I. Unifying Concepts

The student should understand that

...science is an orderly body of unifying concepts based on both qualitative and quantitative observations.
...science is a man-made system that is being constantly reorganized in the light of new observations.

II. Body of Facts

The student should

...use the inquiry method and other scientific methods of problem solving to amass selected basic concepts, laws, and theories of science.
...have knowledge of important events in scientific history and their effects on civilization.
...know about current and often unique scientific research being conducted in Alaska.
...recognize the opportunities for careers in science and technology.

III. Acquiring Skills Through Scientific Processes

The student should be able to

...observe through all his senses wherever practicable, and record his observations in quantitative terms whenever possible.
...include observations of substances that undergo change.
...construct and use classification schemes in terms of properties observed.
...use space-time relations to determine size, shape, rate of motion, etc.
...recognize the importance of a frame of reference in making an observation.
...measure and estimate both in standard and invented units.
...communicate observations with precision using graphs,

maps, scale models, and language art skills.
...draw inferences from observations, and test inferences by experimentation and further observation.
...make predictions based on observations and measurement; interpolate and extrapolate.
...formulate hypotheses based on observation and inference, test hypotheses by experimentation.
...define terms operationally so that by observation and classification, the term is clearly understood.
...formulate models by using information gained through observation, classification, and inference.
...revise or discard models depending on their usefulness in making predictions.
...recognize the importance of controlling variables and accurately recording data.
...exhibit manipulative skills in the use of many laboratory devices.
...apply principles of science toward a better understanding of and an intelligent adjustment to his natural environment.

IV. Developing Attitudes

The student should

...exhibit curiosity in many diversified areas of science.
...approach new problems with an open mind.
...respect objective evidence obtained by scientific inquiry.
...understand the consequences of wise and unwise use of resources, both by the individual and society.
...demonstrate his willingness to learn on his own.
...capitalize on his abilities and interests to a feeling of satisfaction through individual accomplishment.
...recognize and respect the rights of others to express their ideas.
...display a humaneness toward and a wonderment about life in all its myriad forms.
...be aware that information presented by various communication media varies greatly as to validity.

V. Developing Appreciations

The student should

...understand the quantitative nature of science.

OBJECTIVES

...recognize the impact of scientific discovery on society.
...appreciate the cooperative effort that leads to scientific discovery and development of practical applications for new knowledge.
...appreciate man's unique position in his environment.

CONCEPTUAL SCHEMES AND UNIFYING CONCEPTS

CONCEPTUAL SCHEME I:

All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

Unifying Concepts--

1-1 All matter can be reduced to its fundamental particles.
1-2 Under special conditions, matter may be converted to energy and energy to matter.
1-3 Properties of atoms are a function of the organization of their sub-particles.

CONCEPTUAL SCHEME II:

Matter exists in the form of units which can be classified into hierarchies of organizational levels.

Unifying Concepts--

2-1 The atom is the basic building block for all matter.
2-2 The cell is the basic structural and functional unit of living matter.
2-3 Forms of matter have characteristic properties.
2-4 Forms of matter can be found in increasingly complex arrangements.
2-5 Modern classification schemes are based on related properties.

CONCEPTUAL SCHEME III:

The behavior of matter can be described on a statistical basis.

Unifying Concepts--

3-1 Mass, length, and time are the fundamental units of measurement used for scientific work, and all other units are derived from these fundamental units.

3-2 Processes in nature frequently can be described statistically.
3-3 Systems too large or too small for direct observation may be studied by means of models based on statistical descriptions.

CONCEPTUAL SCHEME IV:

Units of matter interact. The bases of ordinary interactions are electromagnetic, gravitational, and nuclear forces.

Unifying Concepts--

4-1 The interactions of matter in the universe are determined by electromagnetic, gravitational, and nuclear forces.
4-2 Certain forces interact directly as to their strengths and inversely as to the square of the distances separating them.
4-3 Energy, in the form of waves, is a fundamental characteristic of interaction of matter.

CONCEPTUAL SCHEME V:

All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

Unifying Concepts--

5-1 Matter and energy cannot be created or destroyed by ordinary means, but can be transformed.
5-2 Many natural processes in both physical and biological systems are periodic.
5-3 In the known physical world, in all processes whether living or non-living, reactions proceed from lower to higher entropy states, that is, from ordered to disordered states.

CONCEPTUAL SCHEMES AND UNIFYING CONCEPTS

CONCEPTUAL SCHEME VI:

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, gaseous, and plasma.

Unifying Concepts--

6-1 Differences in heat content result in changes in motion and/or structure.

CONCEPTUAL SCHEME VII:

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

Unifying Concepts--

7-1 Ecological populations consist of organisms adapted to their particular environment.

7-2 Living things have adaptations that enable them to exist under a wide variety of conditions.

7-3 All life processes involve interactions whereby non-living matter becomes involved in processes and forms characteristic of living matter and eventually returns to the non-living state.

7-4 The earth has undergone great changes in the past and remains in a constant state of change.

7-5 Behavioral patterns of living organisms are subject to change in response to environmental factors.

7-6 Structure is complementary to function.

7-7 The gene pool provides for genetic continuity but mutation, coupled with predictable ratios of gene recombinations, gradually modifies a species through a process of natural selection which can be traced through the fossil record to the present time and is known as evolution.

7-8 The impact of man on the environment can affect changes in the local biome.

7-9 Many processes in both physical and biological

systems are periodic.

7-10 Natural laws apply regardless of the frame of reference but may appear to vary if motion is not uniform.

LEVEL I
PRIMARY

CONCEPTUAL SCHEME I:

All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

1-1 All matter can be reduced to its fundamental particles.

1-11 The child should be able to demonstrate that matter may be reduced to smaller particles by grinding, smashing, heating, and cutting.

CONCEPTUAL SCHEME II:

Matter exists in the form of units which can be classified into hierarchies of organizational levels.

2-1 The atom is the basic building block for all matter.

The child should be able to:

2-11 ...identify some common elements, such as gold, copper, aluminum, mercury.
2-12 ...show in some manner, such as by dissolving a substance, that matter is composed of very small particles.

2-3 Forms of matter have characteristic properties.

The child should be able to:

2-31 ...separate objects into groups on the basis of color, shape, odor, texture, and solubility in water.
2-32 ...distinguish between different states of matter.
2-33 ...order various types of materials according to their strength.
2-34 ...identify some substances by their physical properties.

LEVEL I

2-4 Forms of matter can be found in increasingly complex arrangements.

2-41 The child should be able to realize that the Earth is a member of a solar system.

2-5 Modern classification schemes are based on related properties.

The child should be able to:

2-51 ...place living and non-living objects into the appropriate group.
2-52 ...place pictures of mammals, reptiles, birds, fish, amphibians, and insects into their appropriate group.

CONCEPTUAL SCHEME III:

The behavior of matter can be described on a statistical basis.

3-1 Mass, length, and time are the fundamental units of measurement used for scientific work, and all other units are derived from these fundamental units.

The child should be able to:

3-11 ...measure the length and determine the mass of objects to the nearest whole unit using Metric units and invented units of measure such as paper clips for weight, soda straws for length, etc.
3-12 ...measure time intervals to the nearest minute.

3-2 Processes in nature frequently can be described statistically.

3-21 The child should be able to take measurements of distance and of time and construct a simple graph of his results.

3-3 Systems too large or too small for direct observation may be studied by means of models based on statistical descriptions.

LEVEL I

The child should be able to:

3-31 ...point out land and water areas on a globe.
3-32 ...locate fixed positions on the globe.

CONCEPTUAL SCHEME IV:

Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

4-1 The interactions of matter in the universe are determined by electromagnetic, gravitational, and nuclear forces.

The child should be able to:

4-11 ...demonstrate that a force such as a push or pull affects the direction of objects in motion.
4-12 ...demonstrate that different amounts of force are needed to move objects of varying mass.
4-13 ...demonstrate that different forces are needed to move objects of equal mass which have different coefficients of friction.
4-14 ...separate magnetic from non-magnetic objects.
4-15 ...demonstrate the spatial limitations of magnetic force and describe this as a magnetic field.
4-16 ...demonstrate the attraction and repulsion of magnets.
4-17 ...locate the poles of a magnet.
4-18 ...demonstrate the action-reaction principle.

4-2 Certain forces interact directly as to their strengths and inversely as to the square of distances separating them.

4-21 The child should be able to demonstrate that the force of a magnet is affected by distance.

4-3 Energy, in the form of waves, is a fundamental characteristic of interaction of matter.

LEVEL I

The child should be able to:

4-31 ...demonstrate wave generation in a variety of materials.
4-32 ...measure a wave length to the nearest whole unit.
4-33 ...show by experimental means that light travels in a straight line.
4-34 ...demonstrate that sound waves are vibrations of matter.
4-35 ...demonstrate that sound waves can travel through various media.
4-36 ...demonstrate that wave amplitude is determined by the amount of energy used to generate the wave.
4-37 ...demonstrate that a wave is a path of energy.
4 38 ...identify some objects by the characteristic sounds they produce.

CONCEPTUAL SCHEME V:

All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

5-1 Matter and energy cannot be created or destroyed by ordinary means, but can be transformed.

The child should be able to:

5-11 ...perform experiments that produce chemical changes in matter, and to compare the substances before and after reaction.
5-12 ...demonstrate several ways to produce heat, such as by chemical energy, electrical energy, and friction (mechanical energy).
5-13 ...perform an experiment to show that energy is required to do work.

LEVEL I

5-2 In the known physical world, in all processes, whether living or non-living, reactions proceed from lower to higher entropy states; that is, from ordered to disordered states.

The child should be able to:

5-21 ...describe the earth's cooling after sundown as heat loss.
5-22 ...perform an experiment which demonstrates diffusion.

CONCEPTUAL SCHEME VI:

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, gaseous, and plasma.

6-1 Differences in heat content result in changes in motion and/or structure.

The child should be able to:

6-11 ...group substances according to their states of matter.
6-12 ...produce a change of state by the addition of heat.
6-13 ...diagram the flow of hot and cold air in a room.
6-14 ...demonstrate that a rise in temperature causes an increase in pressure.

CONCEPTUAL SCHEME VII:

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

7-1 Ecological populations consist of organisms adapted to their particular environment.

The child should be able to:

7-11 ...perform experiments to determine how the

growth rate of plants is affected by varying amounts of air, food, water, and light.

7-12 ...compare growth rate of control plants to the rate of those deprived of each of the requirements: air, food, water, and light.

7-13 ...describe a simple food chain.

7-2 Living things have adaptations that enable them to exist under a wide variety of conditions.

The child should be able to:

7-21 ...name some animals in the local environment that hibernate.

7-22 ...group animals in the local environment as carnivorous and those which are herbivorous.

7-23 ...name some animals of the local environment which migrate, such as salmon, caribou, waterfowl, moose, whales, seals, and walrus.

7-24 ...explain how specialized adaptations of organisms enable them to survive wet or dry in environments.

7-25 ...recognize various types of environments (biomes) and identify some of their predominant life forms.

7-3 All life processes involve interactions whereby non-living matter becomes involved in processes and forms characteristic of living matter and eventually returns to the non-living state.

The child should be able to:

7-31 ...relate rate of plant growth to Alaska's long daylight hours in summer.

7-32 ...identify mineral and vegetable elements in soil.

7-33 ...collect and identify seeds of local plants.

7-34 ...relate plant reproduction to animal reproduction.

7-35 ...name ways various animals reproduce.

7-36 ...demonstrate that dormant soils contain

plant life which does not appear until favorable conditions for germination occur.

7-4 The earth has undergone great changes in the past and remains in a continual state of change.

The child should be able to:

7-41 ...describe the characteristics of rocks, such as size, shape, hardness, and texture.
7-42 ...identify places in his local area where erosive forces such as wind, water, temperature, and glaciation are at work.

7-5 Behavioral patterns of living organisms are subject to change in response to environmental factors.

7-51 The child should be able to describe animal behavior patterns caused by mineral elements such as salt in the soil.

7-6 Structure is complementary to function.

7-61 The child should be able to identify certain specialized structures such as fur, feather, and fins, and describe how these structures help the animal to live in his particular environment.

7-7 The gene pool provides for genetic continuity but mutation, coupled with predictable ratios of gene recombinations, gradually modifies a species through a process of natural selection which can be traced through the fossil record to the present time and is known as evolution.

The child should be able to:

7-71 ...identify young by their resemblance to the parent.
7-72 ...show that plant seeds produce plants like those from which the seed came.

7-73 ...compare dinosaurs with animals of today.
7-74 ...describe the environment which was necessary to the dinosaurs.

7-8 The impact of man on the environment can effect changes in the local biome.

The child should be able to:

7-81 ...name some animals which are extinct or which are in danger of becoming extinct because of indiscriminate killing.
7-82 ...list some reasons for and formulate some rules to protect wildlife.
7-83 ...recognize forest fires and erosion of topsoil as two forms of waste of natural resources.
7-84 ...formulate some means by which he personally can conserve resources.

7-9 Many processes in both physical and biological systems are periodic.

The child should be able to:

7-91 ...perform an experiment to demonstrate the water cycle.
7-92 ...recognize high and low tides as a daily repetitive cycle.
7-93 ...show, such as by using a globe and flashlight, that the day and night cycle is a result of the earth's rotation.
7-94 ...demonstrate, such as by using a tilted globe around a central light, that the cycle of the seasons is a result of the earth's rotation around the sun.
7-95 ...name some cyclic occurrences related to seasons, such as the birth of animal young found in his environment (moose, caribou, etc.).
7-96 ...describe phases and rotation of the moon.

LEVEL I

7-10 Natural laws apply regardless of the frame of reference but may appear to vary if motion is not uniform.

The child should be able to:

7-101 ...describe the direction of motion of an object with respect to a chosen frame of reference.

LEVEL II
INTERMEDIATE

CONCEPTUAL SCHEME I:

All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

1-1 <u>All matter can be reduced to its fundamental particles.</u>

1-11 The child should be able to name three of the fundamental particles of atoms--protons, electrons, and neutrons--and describe them as having the same properties regardless of the kind of atom in which they are found.

CONCEPTUAL SCHEME II:

Matter exists in the form of units which can be classified into hierarchies of organizational levels.

2-1 <u>The atom is the basic building block for all matter.</u>

The child should be able to:

2-11 ...describe elements as being composed of like atoms.
2-12 ...perform experiments to show that compounds differ markedly from the elements of which they are composed.
2-13 ...perform a few simple tests which may be used to identify certain elements.

2-2 <u>The cell is the basic structural and functional unit of living matter.</u>

The child should be able to:

2-21 ...identify cells in a tissue.
2-22 ...name the basic parts of a cell.
2-23 ...group representative examples of tissue, organs, and organ systems according to their complexity.

LEVEL II

2-3 Forms of matter have characteristic properties.

The child should be able to:

2-31 ...Weigh and record weights of similar sized objects and calculate volumes by the displacement of water.

2-32 ...group substances according to their crystalline and non-crystalline structure.

2-33 ...separate substances into groups on the basis of solubility in water and other solvents.

2-34 ...distinguish between conductors and non-conductors of electricity.

2-35 ...demonstrate that liquids may pass through solids.

2-36 ...show that solids may diffuse through solids.

2-4 Forms of matter can be found in increasingly complex arrangements.

The child should be able to:

2-41 ...distinguish between atoms, molecules, elements, compounds, and mixtures.

2-42 ...describe our solar system as a part of the Milky Way galaxy.

2-43 ...place in the proper order of complexity, cell, tissue, organ, system.

2-5 Modern classification schemes are based on related subjects.

The child should be able to:

2-51 ...distinguish between vertebrate and invertebrate animals.

2-52 ...separate pictures of warm and cold-blooded animals into related groups.

2-53 ...separate rocks into sedimentary, metamorphic, and igneous groups.

LEVEL II

CONCEPTUAL SCHEME III:

The behavior of matter can be described on a statistical basis.

3-1 Mass, length, and time are the fundamental units of measurement used for scientific work, and all other units are derived from these fundamental units.

The child should be able to:

3-11 ...make fundamental measurements using whole and decimal units.
3-12 ...measure and record time intervals to the nearest second.
3-13 ...record experimental data and construct a graph of the data when appropriate.
3-14 ...read and record measurements from precision instruments such as barometers and ammeters.
3-15 ...invent and use arbitrary systems of measurement.

3-2 Processes in nature frequently can be described statistically.

The child should be able to:

3-21 ...measure, record, and graph changes in velocity and pressure.
3-22 ...calculate a mean for a given set of experimental data.

3-3 Systems too large or too small for direct observation may be studied by means of models based on statistical descriptions.

The child should be able to:

3-31 ...locate positions on the globe in terms of latitude and longitude.
3-32 ...construct models based on interpretation of topographical maps.
3-33 ...construct or illustrate a model representing

the positional order of the planets relative to the sun.

3-34 ...construct models representing crystal-structure.

CONCEPTUAL SCHEME IV:

Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

4-1 <u>The interactions of matter in the universe are determined by electromagnetic, gravitational, and nuclear forces.</u>

The child should be able to:

4-11 ...diagram the earth's magnetic field.
4-12 ...produce static electricity and describe its properties.
4-13 ...demonstrate similarities between electric and magnetic fields.
4-14 ...distinguish between insulators and conductors.
4-15 ...locate the center of gravity of an object.
4-16 ...distinguish between centrifugal and centripetal force.

4-2 <u>Certain forces interact directly as to their strengths and inversely as to the square of the distances separating them.</u>

4-21 ...The child should be able to demonstrate qualitatively the relationship between strength of forces (magnetic, electric, and gravitational) and the distances separating them.

4-3 <u>Energy, in the form of waves, is a fundamental characteristic of interaction of matter.</u>

The child should be able to:

4-31 ...distinguish between transverse and longitudinal waves.
4-32 ...measure the amplitude of a wave.

LEVEL II

4-33 ...count the number of waves for a given unit of time and express it as a frequency.
4-34 ...show that waves may either interfere with or reinforce one another.
4-35 ...offer some evidence that light travels faster than sound.
4-36 ...list examples of work performed by wave energy.

CONCEPTUAL SCHEME V:

All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

5-1 Matter and energy cannot be created or destroyed by ordinary means, but can be transformed.

The child should be able to:

5-11 ...identify chemical change.
5-12 ...show changes of potential to kinetic energy and vice versa.
5-13 ...describe the role of solar energy in nature by tracing energy from the sun to plants.
5-14 ...demonstrate several different forms of energy.
5-15 ...perform energy transfer by the use of simple machines.
5-16 ...state the rule that levers, like other simple machines, trade distances for force.

5-2 In the known physical world, in all processes, whether living or non-living, reactions proceed from lower to higher entropy states, that is, from ordered to disordered states.

LEVEL II

The child should be able to:

5-21 ...correlate temperature and cloud cover.
5-22 ...demonstrate diffusion of a solid in a liquid.
5-23 ...describe disorganization of matter such as weathering and erosion.
5-24 ...demonstrate a system in equilibrium, such as a balanced aquarium.
5-25 ...describe an entropy system, such as the death and decay of a tree during which process energy is released faster than a comparable tree could grow.

CONCEPTUAL SCHEME VI:

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, gaseous, and plasma.

6-1 Differences in heat content result in changes in motion and/or structure.

The child should be able to:

6-11 ...measure expansion and contraction of materials on heating and cooling.
6-12 ...state the rule that heat will spontaneously flow only from hot bodies to cooler ones.
6-13 ...demonstrate the methods of heat transfer.
6-14 ...estimate wind velocities by observation of phenomena about them, either on the land or the water (Beaufort scale).
6-15 ...demonstrate the relationship between heat and phase.
6-16 ...measure pressure increases in gases as temperatures rise.

LEVEL II

CONCEPTUAL SCHEME VII:

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

7-1 Ecological populations consist of organisms adapted to their particular environment.

The child should be able to:

7-11 ...measure, tabulate, and chart comparative growth of plants growing under different conditions.
7-12 ...inventory and compare plant and animal populations in the local environment.
7-13 ...describe food chains on land and in water.

7-2 Living things have adaptations that enable them to exist under a wide variety of conditions.

The child should be able to:

7-21 ...relate plant reactions to their stimuli.
7-22 ...relate migration and dormancy to environmental changes and survival.
7-23 ...compare migration distances and special habits (flocks, herds, schools, or individuals) of animals, especially those of Alaska.
7-24 ...show how the life cycle of some local organism adapts it to its environment.
7-25 ...construct charts showing migration routes.
7-26 ...describe some seasonal adaptations of plants and animals in the local environment.
7-27 ...describe advantages gained by "social" insects.

7-3 All life processes involve interactions whereby non-living matter

becomes involved in processes and forms characteristic of living matter and eventually returns to the non-living state.

The child should be able to:

7-31 ...name the non-living materials from which a plant manufactures its food.
7-32 ...describe the role of decaying plant and mineral matter in supporting growth of plant life.
7-33 ...identify the seed-producing organs of plants.
7-34 ...relate various plant structures to life processes.
7-35 ...distinguish between green and non-green plants.

7-4 The earth has undergone great changes in the past and remains in a continual state of change.

The child should be able to:

7-41 ...relate the positions of the atmosphere, hydrosphere, and lithosphere to their density.
7-42 ...name the layers of the earth, such as by labeling a chart showing relative densities.
7-43 ...make a list of evidence which indicates that the earth is very old.

7-5 Behavioral patterns of living organisms are subject to change in response to environmental factors.

7-51 The child should be able to describe some behavioral changes caused by exposure to excessive moisture or excessive temperature.

7-6 Structure is complementary to function.

7-61 The child should be able to give examples of plants and animals that have structures

which enable them to survive in their particular environment.

7-7 The gene pool provides for genetic continuity but mutation, coupled with predictable ratios of gene recombinations, gradually modifies a species through a process of natural selection which can be traced through the fossil record to the present time and in known as evolution.

The child should be able to:

7-71 ...discuss a diagram of the life cycle of an insect (such as a mosquito) showing the process of metamorphosis.
7-72 ...construct a diagram or conduct an experiment to describe the life cycle of a plant from seed to seed.
7-73 ...describe the basis for division of time into geologic eras.

7-8 The impact of man on the environment can effect changes in the local biome.

The child should be able to:

7-81 ...describe some causes and effects of soil erosion.
7-82 ...differentiate between renewable and nonrenewable resources.
7-83 ...describe interrelationships of living things with each other and with their physical environment as the key to sound conservation practices.

7-9 Many natural processes in both physical and biological systems are periodic.

The child should be able to:

7-91 ...demonstrate the mechanisms of the water cycle.

LEVEL II

7-92 ...relate the gravitational attractions between the sun, moon, and earth to high and low tides.

7-93 ...demonstrate, such as by using a light and two objects, lunar phases and eclipses.

7-94 ...demonstrate that the moon revolves around the earth with one side always showing.

7-95 ...construct a diagram of the earth and sun to show the cause of day and night, such as by using arrows to show the direction of the earth's rotation.

7-96 ...explain the cycle of the seasons such as by constructing a diagram showing both the tilt of the earth and the shape of its orbit.

7-10 Natural laws apply regardless of the frame of reference but may appear to vary if motion is not uniform.

The child should be able to:

7-101 ...describe the combinations of motions that an object can undergo (translocation, rotation, vibration).

LEVEL III
JUNIOR HIGH

CONCEPTUAL SCHEME I:

All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

1-1 All matter can be reduced to its fundamental particles.

The student should be able to:

1-11 ...describe electrons, protons, and neutrons in terms of charge and mass.
1-12 ...cite evidence which indicates that the mass of an atom is concentrated in the nucleus.
1-13 ...describe some of the characteristic effects of alpha and beta particles and gamma radiation.

1-2 Under special conditions, matter may be converted to energy and energy into matter.

The student should be able to:

1-21 ...indicate the sun and stars as examples of matter-energy transformations.
1-22 ...cite examples of controlled and uncontrolled matter-energy transformations.
1-23 ...state conditions necessary for a chain reaction.
1-24 ...describe some beneficial applications of atomic energy.

1-3 Properties of atoms are a function of the organization of their sub-particles.

The student should be able to:

1-31 ...recognize that in one model of the atom, electrons are described as moving about in

various paths and patterns.

1-32 ...construct a diagram or a model when given the atomic and mass numbers of an atom.

1-33 ...describe radioactivity as an unstable condition of the nucleus.

CONCEPTUAL SCHEME II:

Matter exists in the form of units which can be classified into hierarchies of organizational levels.

2-1 The atom is the basic building block for all matter.

The student should be able to:

2-11 ...describe the relative order of bond strength among the parts of the molecule.

2-12 ...differentiate between covalent and ionic bonds.

2-13 ...perform a few simple tests which may be used to identify certain compounds.

2-14 ...demonstrate the particulate nature of matter, such as by explaining the disappearance of snow at temperatures below freezing (subliming).

2-2 The cell is the basic structural and functional unit of living matter.

The student should be able to:

2-21 ...distinguish between plant and animal cells.

2-22 ...identify certain specialized cells and their tissue of origin.

2-3 Forms of matter have characteristic properties.

The student should be able to:

2-31 ...calculate densities of unknown objects

by experimental methods.

2-32 ...identify selected unknown substances by the use of their melting and boiling points.

2-33 ...separate metals and non-metals on the basis of luster, reflection of light, malleability, and ductility.

2-34 ...identify certain minerals by various physical and chemical tests.

2-35 ...demonstrate that the space occupied by some solutions is less than that occupied by the solute and solvent separately.

2-4 Forms of matter can be found in increasingly complex arrangements.

The student should be able to:

2-41 ...test certain substances to determine whether they are mixtures or compounds.

2-42 ...distinguish between physical and chemical changes.

2-43 ...relate our galaxy to the universe.

2-44 ...relate crystal size to rate of crystal growth.

2-45 ...order from simple to complex, cell, tissue, organ, system, and organism.

2-5 Modern classification schemes are based on related properties.

The student should be able to:

2-51 ...group living things on the basis of specialized structures.

2-52 ...identify some substances by their characteristic crystal structure.

2-53 ...state characteristics which separate living from non-living things.

CONCEPTUAL SCHEME III:

The behavior of matter can be described on a statistical basis.

LEVEL III

3-1 Mass, length, and time are the fundamental units of measurement used for scientific work, and all other units are derived from these fundamental units.

The student should be able to:

3-11 ...make fundamental measurements using metric units.
3-12 ...calculate derived units such as volume, density, and velocity.
3-13 ...use precision instruments.
3-14 ...demonstrate the relative degree of accuracy of experimental measurements.
3-15 ...use the proper number of significant figures when reporting experimental results.
3-16 ...describe stellar distances in terms of light years.
3-17 ...record time intervals to the nearest tenth of a second.

3-2 Processes in nature frequently can be described statistically.

The student should be able to:

3-21 ...interpret experimental results based on student-constructed graphs and charts.
3-22 ...demonstrate the validity of the "Laws of Chance" by a simple experiment.

3-3 Systems too large or too small for direct observations may be studied by means of models based on statistical descriptions.

The student should be able to:

3-31 ...construct or illustrate selected models of atomic structure.
3-32 ...construct or illustrate selected molecular models.
3-33 ...distinguish between models which are miniaturizations of a tangible system and

those which are physical representations of an abstract idea.

CONCEPTUAL SCHEME IV:

Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

4-1 The interactions of matter in the universe are determined by electromagnetic, gravitational, and nuclear forces.

The student should be able to:

4-11 ...relate the location of auroral displays to the shape of the earth's magnetic field.
4-12 ...demonstrate that magnetic fields are produced by moving electrons.
4-13 ...describe and predict compass variations at various positions on the earth.
4-14 ...distinguish between weight and mass.
4-15 ...distinguish between rolling friction and sliding friction.
4-16 ...relate strength of current to the number of magnetic lines of force cut per unit of time.
4-17 ...distinguish between alternating and direct current.
4-18 ...state the domain theory of magnetism.
4-19 ...describe the "space" within the atom as an electromagnetic field.
4-190 ...demonstrate electrostatic force.

4-2 Certain forces interact directly as to their strengths and inversely as to the square of the distances separating them.

The student should be able to:

4-21 ...use the Inverse Square Law to explain the distribution of wave energy in light and other types of electromagnetic phenomena.

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4-22 ...use the Inverse Square Law to explain decrease of loudness of sound and decrease of magnetic and gravitational attraction with increasing distances.

4-3 Energy, in the form of waves, is a fundamental characteristic of interaction of matter.

The student should be able to:

4-31 ...order the members of the electromagnetic spectrum from lowest to highest frequency.
4-32 ...show that frequency and wave length are related.
4-33 ...describe the modification of wave behavior as different media are encountered.
4-34 ...show that the pitch of a sound depends on its frequency.
4-35 ...describe how a depth finder operates.
4-36 ...describe differences in order of magnitude of energy involved in nuclear, chemical, electrical, magnetic, and gravitational interactions in a given system.
4-37 ...describe polarized light as an ordered arrangement of wave energy.

CONCEPTUAL SCHEME V:

All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter-energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

5-1 Matter and energy cannot be created or destroyed by ordinary means, but can be transformed.

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The student should be able to:

5-11 ...state the Law of Conservation of Matter and apply it to an experimental situation.
5-12 ...relate the Law of Conservation of Energy to a sequence of energy changes, such as those involved when the mechanical energy of falling water is converted to electrical energy.
5-13 ...distinguish between kinetic and potential energy.
5-14 ...demonstrate, such as by using the inclined plane, that friction is resistance to movement when one object slides or rolls in contact with another.
5-15 ...describe the effect of friction on the efficiency of machines.
5-16 ...name many devices that are used to change the energy of an electric current into other forms of energy.
5-17 ...demonstrate that vibrations are a form of mechanical energy which can produce sound.
5-18 ...state the rule that every chemical change is accompanied by an energy change.
5-19 ...discuss the fact that much of the effective heat energy received by the arctic regions during the summer is used up in changing ice to water.
5-190 ...describe photosynthesis in terms of energy transfer.

5-2 In the known physical world, in all processes, whether living or non-living, reactions proceed from lower to higher entropy states; that is, from ordered to disordered states.

The student should be able to:

5-21 ...show that crystal fractures and earth faults are the result of stresses and strain.
5-22 ...describe the energy release in an earthquake in terms of the "work" it does.
5-23 ...describe the theory of isostasy as an

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equilibrium state such as by interpreting a diagram of a cross-section of the crust of the earth.

5-24 ...identify examples of equilibrium conditions in nature such as predator-prey relationships.

5-25 ...state the rules that decay releases energy and food-making absorbs energy, and that generally the rate of decay is faster than the rate of food-making.

5-26 ...describe the Red Shift as a Doppler effect as well as evidence for an expanding universe.

5-27 ...describe the interaction of plants and animals in maintaining oxygen and carbon dioxide cycles.

CONCEPTUAL SCHEME VI:

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, gaseous, and plasma.

6-1 Differences in heat content result in changes in motion and/or structure.

The student should be able to:

6-11 ...interpret Brownian movement as evidence of molecular motion.

6-12 ...work problems involving quantitative aspects of heat including those related to change of state.

6-13 ...give examples of thermal currents.

6-14 ...distinguish between heat and temperature.

6-15 ...demonstrate that evaporation is a cooling process.

6-16 ...define sublimation and demonstrate it by experimental means

6-17 ...describe heat as a form of kinetic energy.

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6-18 ...demonstrate the relationship between heat and phase.

CONCEPTUAL SCHEME VII:

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

7-1 Ecological populations consist of organisms adapted to their particular environment.

The student should be able to:

7-11 ...measure, tabulate, and chart comparative growth rates of control plants and plants receiving specific amounts of mineral nutrients while being grown in water.
7-12 ...inventory and compare plant and animal populations within an ecosystem.
7-13 ...inventory and interpret local population sizes in terms of the pyramid of numbers.

7-2 Living things have adaptations that enable them to exist under a wide variety of conditions.

The student should be able to:

7-21 ...recognize that estivation and hibernation are metabolic changes by relating them to temperature, pulse rate, and change in body rate.
7-22 ...relate seasonal changes, such as color changes of ptarmigan and snowshoe rabbits, to survival.

7-3 All life processes involve interactions whereby non-living matter becomes involved in processes and forms characteristic of living matter and eventually returns to the non-living state.

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The student should be able to:

7-31 ...describe ways in which fungi help to break down vegetable and animal matter.
7-32 ...order forms of animal and plant life from simple to more complex.
7-33 ...relate the fossil record to present forms.
7-34 ...compare the manner in which life processes are carried on by different groups of organisms.

7-4 The earth has undergone great changes in the past and remains in a constant state of change.

The student should be able to:

7-41 ...compare methods used in mineral prospecting.
7-42 ...list reasons for the accumulation of mineral deposits.
7-43 ...read geologic survey maps.
7-44 ...identify mountain forms according to their geologic origin.
7-45 ...describe local effects of the Ice Ages.
7-46 ...describe ways the geologic record discloses the earth's history.

7-5 Behavioral patterns of living organisms are subject to change in response to environmental factors.

The child should be able to:

7-51 ...give examples of behavioral changes caused by overcrowding.
7-52 ...describe behavioral changes caused by the sensation of weightlessness.

7-6 Structure is complementary to function.

LEVEL III

The student should be able to:

7-61 ...name some specialized structures and relate them to the function they perform.
7-62 ...take some specific structure and give examples to illustrate how it has been variously modified to suit a number of different environments.

7-7 The gene pool provides for genetic continuity but mutation, coupled with predictable ratios of gene recombinations, gradually modifies a species through a process of natural selection which can be traced through the fossil record to the present time and is known as evolution.

The student should be able to:

7-71 ...relate life cycles and metamorphosis to evolutionary processes.
7-72 ...name and describe different forms of plant and animal reproduction, both sexual and asexual.
7-73 ...describe some animals, such as the planaria, which may reproduce either sexually or asexually, and which also retain the ability to regenerate.
7-74 ...cite some examples of "hybrid vigor," including some plants and animals which have been developed especially for Alaska.
7-75 ...recognize some index fossils and relate them to the geologic timetable.
7-76 ...cite evidence in the fossil record which indicates present-day animals or plants are products of evolution.
7-77 ...show how limited natural selection alters the evolutionary process by citing examples from such isolated areas as Australia and the Galapagos Islands.

7-8 The impact of man on the environment can effect changes in the local biome.

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The child should be able to:

7-81 ...describe man's responsibility to restore the biome as nearly as he found it after industrial processes have been carried out.

7-82 ...show how man can control the destructive processes of nature by such artificial means as dams, reforestation, terracing, and replanting grass and trees following industrial operations.

7-83 ...cite examples of some favorable and some unfavorable ways in which man has affected his local environment.

7-84 ...show his understanding of the need for conservation laws in fish, game, and forestry to prevent extinction, such as by naming some extinct animals like the passenger pigeon and listing the causes of their extinction.

7-85 ...show his understanding of game and timber regulations in Alaska by relating each law mentioned to the background reasons for the law.

7-9 Many natural processes in both physical and biological systems are periodic.

The student should be able to:

7-91 ...identify the rising and setting of the sun, moon, and stars as cyclic results of the earth's periodic rotation.

7-92 ...describe reasons for the periodic appearance of constellations.

7-93 ...recognize constellation and star positions in star charts for different months.

7-94 ...interpret the geologic timetable in terms of the sequence of mountain building and peneplaning.

7-95 ...give examples of periodic fluctuations in

ecological populations, such as "no see 'ems," mosquitoes, lemmings, deer, and wolves.

7-96 ...relate the regular repetition of the properties of elements when arranged by atomic number of outer shell electrons.

7-97 ...describe the life cycle of a star.

7-98 ...identify some periodic factors in the life cycle of the salmon.

7-10 Natural laws apply regardless of the frame of reference but may appear to vary if motion is not uniform.

The student should be able to:

7-101 ...describe the combinations of motions that an object can undergo (translocation, rotation, vibration) as observed from within and from outside a system.

LEVEL IV
SENIOR HIGH

CONCEPTUAL SCHEME I:

All matter is composed of units called fundamental particles; under certain conditions these particles can be transformed into energy and vice versa.

1-1 All matter can be reduced to its fundamental particles.

The student should be able to:

1-11	... discuss atomic theory in terms of its historical development	C, P, PS, ES[1]
1-12	...select isotopes of an element from a collection of nuclear models.	A

1-2 Under special conditions, matter may be converted to energy and energy to matter.

The student should be able to:

1-21	...develop operational definitions of matter and energy.	A
1-22	...predict the products of nuclear changes involving loss or gain of alpha or beta particles.	C, P, PS
1-23	...order nuclear emissions from those of lowest energy to those of highest energy.	B, C, P, PS
1-24	...calculate the age of a material using radioactive data.	A
1-25	...identify types of nuclear reactions in natural phenomena such as fission, fusion, natural decay, and nuclear disintegration.	A
1-26	...predict the energy equivalent of a given mass.	P

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1 Key: B, Biology; C, Chemistry; P, Physics, PS, Physical Science; ES, Earth Science; A, could apply to all science areas.

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1-3 Properties of atoms are a function of the organization of their sub-particles.

The student should be able to:

1-31	...construct a diagram or model of an atom when given the atomic and mass number of the element.	A
1-32	...place an element in the proper periodic group using its electron configuration.	C
1-33	...order sets of ionization potential and atomic radius data from the most metallic to the least metallic.	C
1-34	...predict the nature of bonds from electronegativity differences.	C
1-35	...classify given elements into groups or families according to their properties.	C, P, PS, ES
1-36	...predict properties of an element when given the atomic radius and the number of electrons available for electron gain, loss, or sharing.	C

CONCEPTUAL SCHEME II:

Matter exists in the form of units which can be classified into hierarchies of organizational levels.

2-1 The atom is the basic building block for all matter.

The student should be able to:

2-11	...construct diagrams to distinguish between electrovalence, covalence, coordinate covalence, and metallic bonding.	B, C, P, PS

2-2 The cell is the basic structural and functional unit of living matters.

The student should be able to:

2-21 ...associate sub-cellular structures

	with their functions.	B
2-22	...trace the major historic developments leading to the cell theory.	B

2-3 Forms of matter have characteristic properties.

The student should be able to:

2-31	...identify those properties of substances which are functions of the arrangement of their sub-units: atoms, ions, or molecules.	A
2-32	...identify substances by various physical and chemical tests.	A
2-33	...select from a set of substances those which are colloidal systems.	B, C
2-34	...group substances which have similar chemical compositions.	A
2-35	...demonstrate that matter is porous.	A

2-4 Forms of matter can be found in increasingly complex arrangements.

The student should be able to:

2-41	...order systems of matter: atoms to universe.	A

2-5 Modern classification schemes are based on related properties.

The student should be able to:

2-51	...identify and name properties of a set of objects or organisms which can be used as a basis for classification.	A
2-52	...use a classification system or key to place an organism or an object into its relative position in the scheme.	A
2-53	...construct a simple classification scheme.	A

LEVEL IV

CONCEPTUAL SCHEME III:

The behavior of matter can be described on a statistical basis.

3-1 Mass, length, and time are the fundamental units of measurement used for scientific work, and all other units are derived from these fundamental units.

The student should be able to:

3-11	...describe the current physical bases for the fundamental units of the metric (cgs) system.	A
3-12	...use precision instruments.	A
3-13	...demonstrate the relative degree of accuracy of experimental measurements.	A
3-14	...use the proper number of significant figures when reporting experimental results.	A
3-15	...use tables and handbooks.	A
3-16	...use scalar and vector quantities.	P, PS, ES
3-17	...collect and analyse data using the proper units and standard symbols.	A
3-18	...make calculations using the mole concept.	C, P

3-2 Processes in nature frequently can be described statistically.

The student should be able to:

3-21	...demonstrate the laws of probability and apply them to physical and biological phenomena.	A

3-3 Systems too large or too small for direct observation may be studied by means of models based on statistical descriptions.

The student should be able to:

3-31	...describe, illustrate, or construct to scale models of matter at different	

levels of complexity. A

CONCEPTUAL SCHEME IV:

Units of matter interact. The bases of all ordinary interactions are electromagnetic, gravitational, and nuclear forces.

4-1 The interactions of matter in the universe are determined by electromagnetic, gravitational, and nuclear forces.

The student should be able to:

4-11 ...demonstrate that oxidation-reduction reactions are processes which involve electron transfer. A

4-12 ...interpret certain changes in matter as evidence of the existence of sub-atomic particles. A

4-13 ...diagram or illustrate the domain theory of magnetism. P, PS, ES

4-14 ...demonstrate the effects of electrostatic, magnetic, and gravitational forces. A

4-15 ...demonstrate that magnetic fields are produced by moving electrons. C, P, PS

4-2 Certain forces interact directly as to their strengths and inversely as to the square of the distances separating them.

The student should be able to:

4-21 ...derive and apply the Inverse Square Law to sound, light, magnetism, radiation, and gravity. C, P, PS, ES

4-3 Energy in the form of waves, is a fundamental characteristic of interaction of matter.

The student should be able to:

4-31 ...use diagrams or a helix to demonstrate the characteristics of transverse

	and longitudinal waves.	P, PS, ES
4-32	...predict modifications of wave motion under various conditions.	C, P, PS, ES
4-33	...determine the relationship of wave length to color and pitch.	C, P, PS, ES
4-34	...compare the orders of magnitude of energy involved in nuclear, chemical, electrical, magnetic, and gravitational interactions in a given system.	C, P, PS, ES
4-35	...demonstrate the polarization of wave energy.	P, PS
4-36	...relate the wave energy of water to erosion.	ES

CONCEPTUAL SCHEME V:

All interacting units of matter tend toward equilibrium states in which the energy content (enthalpy) is a minimum and the energy distribution (entropy) is most random. In the process of attaining equilibrium, energy transformations or matter transformations or matter energy transformations occur. Nevertheless, the sum of energy and matter in the universe remains constant.

5-1 Matter and energy cannot be created or destroyed by ordinary means, but can be transformed.

The student should be able to:

5-11	...describe metabolism in terms of energy transformations.	B
5-12	...describe photosynthesis in terms of energy transformation.	B
5-13	...design an experiment to illustrate the Law of Conservation of Matter.	A
5-14	...design an experiment which demonstrates the relationship of kinetic energy and potential energy to the Law of Conservation of Energy.	A
5-15	...trace energy transfer in natural phenomena, e.g., water cycle, food web, etc.	A
5-16	...trace energy conversions in	

electrical, chemical, heat, light, sound, and/or mechanical systems. A

5-2 In the known physical world, in all processes, whether living or non-living, reactions proceed from lower to higher entropy states; that is, from ordered to disordered states.

The student should be able to:

5-21 ...identify examples of interactions between internal and external forces shaping the earth's surface. ES

5-22 ...accumulate evidence that living is the pursuit of energy. B

5-33 ...design experiments to illustrate the laws of thermodynamics. A

5-34 ...accumulate evidence of biological, chemical, and physical equilibria. A

5-35 ...relate the concept of base level to increase in entropy, e.g., decrease in particle size. ES

5-36 ...construct experiments to test factors controlling solution processes and solubility equilibrium. A

CONCEPTUAL SCHEME VI:

One of the forms of energy is the motion of units of matter. Such motion is responsible for heat and temperature and for the states of matter: solid, liquid, gaseous, and plasma.

6-1 Differences in heat content result in changes in motion and/or structure.

The student should be able to:

6-11 ...construct an experiment which tests the Kinetic-Molecular Theory. A

6-12 ...demonstrate diffusion and explain it in terms of molecular motion. A

6-13 ...relate thermal currents to environmental conditions. B, ES

6-14 ...predict the effects of heat on chemical reactions. A

LEVEL IV

6-15	...demonstrate the effects of temperature and pressure on the behavior of gases.	A
6-16	...exhibit awareness of the plasma state of matter.	C, P

CONCEPTUAL SCHEME VII:

All matter exists in time and space and, since interactions occur among its units, matter is subject in some degree to changes with time. Such changes may occur at various rates and in various patterns.

7-1 Ecological populations consist of organisms adapted to their particular environment.

The student should be able to:

7-11	...inventory and correlate populations with their ecological environment.	B
7-12	...use local ecosystems to identify stages in succession of communities.	B

7-2 Living things have adaptations that enable them to exist under a wide variety of conditions.

The student should be able to:

7-21	...identify those adaptations necessary for aquatic life, terrestial existence, and life under extreme environmental conditions.	B, ES
7-22	...describe self-perpetuation in terms of homeostasis, reproduction, and adaptation.	B
7-23	...describe how specific needs of living things furnish clues to the past history of the earth.	B, ES
7-24	...formulate theories to explain why some organisms have become extinct.	B, ES
7-25	...explore the advantages and disadvantages of specialization and generalization in life forms.	B, ES

7-3 All life processes involve interactions whereby non-living matter becomes involved in processes and forms characteristic of living matter and eventually returns to the non-living state.

The student should be able to:

7-31 ...diagram the role of organisms in the cycling of materials. B, C, ES

7-4 The earth has undergone great changes in the past and remains in a continual state of change.

The student should be able to:

7-41 ...reconstruct the geologic history of an area from a geologic map or diagram. ES

7-42 ...develop and evaluate hypotheses to explain geologic problems identified in the field or on maps. ES

7-43 ...relate different types of mineralization to their causes. ES

7-5 Behavioral patterns of living organisms are subject to change in response to environmental factors.

The student should be able to:

7-51 ...debate the possibility of extra-terrestrial life. B, ES

7-52 ...design an experiment that produces a behavioral change in an organism by varying only one environmental factor. B

7-6 Structure is complementary to function.

The student should be able to:

7-61 ...link analogous structure with their basic function. B, ES

7-62 ...recognize homologous structures regardless of modification for different functions. B, ES

LEVEL IV

7-7 The gene pool provides for genetic continuity but mutation, coupled with predictable ratios of gene recombinations, gradually modifies a species through a process of natural selection which can be traced through the fossil record to the present time and is known as evolution.

The student should be able to:

7-71	...recognize that the medium of natural organic evolution is the Mendelian population, the raw materials are the inheritable variations, and the mechanism is natural selection.	B
7-72	...realize man's ability to affect the evolutionary direction of organisms, including his own.	B, ES
7-73	...discuss the role of sexual reproduction in bringing about diverse life forms.	B
7-74	...cite specific causes and examples of mutations.	B, PS, ES
7-75	...cite evidences for the unity of life as revealed by taxonomy, biochemistry, embryology, and paleontology.	B, C, ES
7-76	...exhibit an appreciation for the great diversity of life that has resulted from an accumulation of changes within organisms.	B, ES
7-77	...use index fossils to date rocks.	ES
7-78	...trace the evolution of some animal from its earliest known ancestors.	B, ES

7-8 The impact of man on the environment can effect changes in the local biome.

The student should be able to:

7-81	...evaluate man's use of chemical and/or biological methods of population control.	B

LEVEL IV

7-82 ...develop a multiple use program for utilization of a local natural resource. B, ES

7-83 ...cite examples showing the need for action on the part of all members of society to make intelligent decisions in managing their environment. A

7-9 Many natural processes in both physical and biological systems are periodic.

The student should be able to:

7-91 ...construct an experiment to study the life cycles of organisms exhibiting metamorphosis. B

7-92 ...devise a means of illustrating the correlation between some biologic rhythms and celestrial motions. B

7-10 Natural laws apply regardless of the frame of reference but may appear to vary if motion is not uniform.

The student should be able to:

7-101 ...describe situations which show that apparent motion is dependent upon the relative position of the observer. P, PS, ES

SAFETY IN SCIENCE INSTRUCTION
GRADES K - 12

All science programs must stress safety for the protection of students and teachers. Good safety procedures in science instruction cultivate attitudes that will persist beyond the formal schooling of the student. This list of practices which will help prevent hazardous situations is not comprehensive: it is expected that each teacher will develop supplementary methods to meet local conditions.

I. BACTERIA

A. Teachers without experience in proper laboratory techniques should not culture bacteria.

B. Only non-pathogens should be cultured.

C. Cultures should be sterilized before disposal of the media.

II. ANIMALS

A. Dissections should not be attempted without knowledge and use of proper procedures.

B. Rubber gloves should be worn while dissecting warm-blooded animals which have not been preserved.

C. Diseased animals should never be dissected or retained in the classroom.

D. Consult a veterinarian or medical doctor before dissecting any wild animal. Rabies, tularemia, or other communicable diseases may be present.

E. Use caution when handling parakeets and parrots, as they are carriers of psittacosis.

III. POISONOUS PLANTS

A. Unidentified plants should never be tasted. Examples

of poisonous plants found in Alaska are

1. Certain mushrooms and other fungi
2. Baneberry
3. Narcissus-flowered Anemone
4. Poison Water Hemlock
5. Wild Sweetpea
6. Nootka Lupine
7. Vetch
8. False Hellebore
9. Death Camas

B. For detailed information consult:

Virginia L. Wells, and Phyllis E. Kemption, Know Alaska's Mushrooms, Cooperative Extension Service Publication #6, University of Alaska and U.S. Department of Agriculture, 1962. (25¢)

Christine A. Heller, Wild Edible and Poisonous Plants of Alaska, Cooperative Extension Service Publication #40, University of Alaska and U.S. Department of Agriculture, 1966. (50¢)

IV. CHEMICALS

A. Chemicals such as ether, acetone, silver nitrate, phosphorus, sodium, mercury, cyanide, and others can be extremely dangerous substances. They should not be handled by persons who are not familiar with their hazardous properties. The dangers of ether warrant special mention. Partially filled cans of ether should be emptied because ether-air mixtures become highly explosive on standing. Ether should only be discarded in well ventilated areas, such as outdoors or in a fume hood.

B. Have a chemical first aid chart available at all times.

C. Don't taste any chemical.

D. Wear safety glasses during laboratory experiments.

E. When heating test tubes, keep open end pointed away from classmates.

F. Wash out containers such as duplicator fluid cans before using in the laboratory.

G. In the production of oxygen, never use potassium chlorate ($KCLO_3$) and manganese dioxide. Many serious accidents have occurred with this combination.

H. EXTREME care should be taken during the production and testing of hydrogen. Hydrogen and air mixtures are explosive and only very small volumes should be used in testing.

I. Dilute spilled acids and bases with water before wiping up.

J. Acids and bases spilled on hands and clothing should be flooded with water.

K. NEVER ADD WATER TO A CONCENTRATED ACID as a violent release of heat and steam will immediately cause acid to be spattered. Always add the acid to the water while stirring.

L. The halogens--fluorine, chlorine, bromine, and iodine--are all toxic and dangerous substances producing "burns" that are slow to heal. Avoid contact and inhalation.

M. A 30% solution of hydrogen peroxide "burns" flesh and should be handled by the teacher only. Only 3% solutions should be used.

N. Partially filled bottles of many liquids will have built up considerable vapor pressure. Fumes may be toxic. Open only in areas where there is adequate ventilation.

V. CLASSROOM PROCEDURES

A. Sterile disposable lancets should be used to lance fingers. Alcohol is not adequate for destroying all pathogens (e.g., those causing hepatitis). If needles are used, flaming is an adequate means of sterilization.

B. Puncturing the seal of CO_2 cartridges with needles is

very dangerous. A special tool designed for this purpose should be used.

C. Experimentation with rockets and fuel propulsion systems should be discouraged unless a rocket expert can direct the experiments. If experiments are conducted, commercially prepared engines with propellants should be used.

D. Many volatile liquids such as the alcohols are flammable and should never be used near an open flame.

E. Fire blankets should be readily available wherever burners are used.

F. Avoid direct observations of solar eclipses through negatives, pin holes, etc., because of the possibility of permanent retinal damage. A recommended procedure is to view the image of the eclipse as it is projected on a screen through a pin hole camera.

G. Improper use of glassware is the cause of many injuries. Lubricants and towels should be used when inserting glass tubing or thermometers into rubber stoppers.

H. Mouth pipetting should be prohibited.

I. When chipping and breaking rocks, care should be taken to protect the eyes. A geology pick should not be used as a chisel because slivers of steel may fly off.

J. All electrical apparatus should be used under proper supervision.

K. All student projects involving electricity should be closely supervised by qualified personnel.

CRITERIA FOR IMPLEMENTATION OF THE SCIENCE PROGRAM[1]

Many persons become involved in the science program. The degree to which an individual is involved is determined by his position, the grade level or levels at which he is working, and the specific organization of the program. It is hoped that these guidelines will be useful to science teachers, curriculum advisors, principals, superintendents, and others involved in improving the science program of Alaska.

If the science program is to be of maximum value, some criteria for measuring its effectiveness should be established. The following checklist of questions pointing toward the desirable outcomes in a science program has been developed for the purpose of self-evaluation. It is realized that not every science program will meet every one of the following criteria, nor will they be met to the same degree. The criteria are presented as suggestions toward which persons involved in the elementary science program can focus their attention.

I Personnel in the Science Program

A. Is a qualified consultant available in science and in elementary education?

B. Do science teachers have an adequate background in science content and methods of teaching science?

C. Are continuing in-service training programs in science content and methods available?

D. Is the community being made aware of the importance of science in the curriculum?

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[1]Abstracted From:

Joseph Zafforoni, New Developments in Elementary School Science, National Science Teachers Association, Washington, D. C., 1963;

Nelson B. Henry, "Rethinking Science Education," The Fifty-Ninth Yearbook of the National Society for the Study of Education, University of Chicago Press, Chicago, Illinois, 1960; and

The Superintendent in the Science Program (Bulletin 8), Bulletin of the Texas Association of School Administors, Austin, Texas, October, 1956.

CRITERIA

II. The Science Program

A. Do the science experiences at each grade level build on experiences in previous grades and lead to experiences in subsequent grades?

B. Is an administrator responsible for providing direction and for assisting teachers in developing the science program?

C. Is the science program provided for all children?

D. Is opportunity provided to extend the horizons of those children who are especially fascinated with science through enrichment work and such co-curricular activities as science clubs, science fairs, and public exhibits?

E. Do students have an opportunity to explore in each of the several large areas of science?

F. Do programs recognize and apply present-day knowledge of the behavioral patterns and growth processes of children?

G. Do classroom science activities show promise for developing the highest quality of which the students are capable?

H. Do programs show a sequence of learning activities that develop both the products and the processes of science?

I Is sufficient time provided for instruction in science?

III. Methods in the Science Program

A. Do students have the opportunity to participate in experiments, demonstrations, field trips, construction projects, library research, group discussions, and discussions with informed members of the community?

B. Is provision made for exploration of current research in Alaska?

C. Are the science program and its activities clearly aimed at developing the attitudes and skills of inquiry?

D. Are subject matter and teaching methods most appropriate to the situation in which they are being used?

E. Is evaluation of the student consistent with the aims and objectives of the modern science program?

IV. Review and Evaluation of the Science Program

A. Are parents regularly informed of the progress of their children in science?

B. Is provision made for constant and thorough analysis and revision of the school science program?

C. Is the school science program constantly evaluated by all who participate in it--including the students?

V. Facilities and Equipment in the Science Program

A. Is a wide variety of current science reference materials such as books, pamphlets, and periodicals easily acessible to the students?

B. Are such things as films, film strips, TV programs, slides, records, and the equipment for presenting them readily available?

C. Has a series of science textbooks been adopted to assist in the sequential development of the science program?

D. Is a professional library of science materials available to the teacher?

E. Are appropriate facilities available for children to study science?

F. Is the teacher able to obtain small items of science materials as they are needed?

G. Are local supplies and materials used in the science program when appropriate?

H. Is adequate storage space available for science equipment, supplies, and materials, and is it readily accessible to the classroom?

CRITERIA

I. Are classrooms planned for the display of science projects, exhibits, and collection?

J. Are classrooms planned for the projection of visual materials and for the use of other instructional media?

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